

# Achieve Optimal Routing and Reduce BGP Memory Consumption

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## Introduction

This document illustrates how to achieve a high degree of optimal routing in an enterprise network connected to multiple Internet service providers (ISPs), while minimizing the memory requirements of the Border Gateway Protocol (BGP) routers. This is achieved by using AS\_PATH filters for accepting only routes originated from an ISP and its directly connected autonomous systems, instead of receiving the full BGP routing table from an ISP.

## Prerequisites

### Requirements

There are no specific requirements for this document.

### Components Used

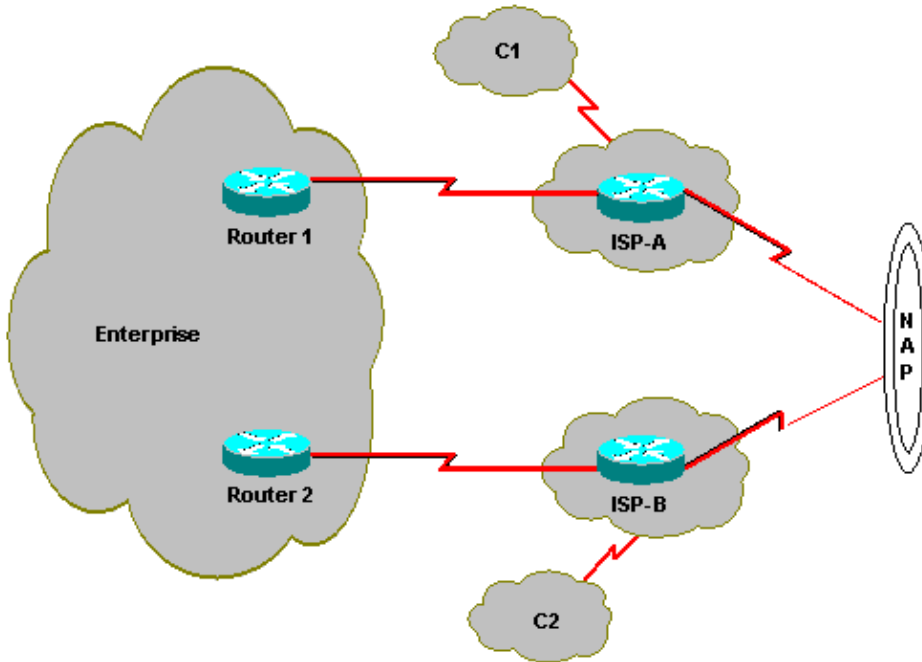
This document is not restricted to specific software and hardware versions.

### Conventions

For more information on document conventions, refer to the Cisco Technical Tips Conventions.

## Background Information

This section provides a network diagram as an example. In the example, you filter incoming BGP updates at Router 1 and Router 2 to accept the routes of the ISP and the routes of the directly connected autonomous system. Router 1 is accepting routes for ISP-A and its directly connected autonomous system C1. Similarly, Router 2 is accepting routes for ISP-B and C2. The rest of the networks, which do not belong to the ISPs and their customer autonomous system, follow the default route pointing toward ISP-A or ISP-B, depending on the enterprise routing policy.



You can observe how memory utilization varies when Router 1 accepts the complete BGP routing table of approximately 100,000 routes from its ISP, as compared to when you apply inbound AS\_PATH filters on Router 1.

**Note:** The actual number of prefixes that make up a full feed may vary. The values in this document serve only as an example. Route-servers can provide a good idea of how many prefixes make up a full BGP table. (For more information on route-servers, refer to Traceroute.org.)

## BGP Router Receives Complete BGP Routing Table

This is the configuration of Router 1:

Router 1
<pre>hostname R1 ! router bgp XX  no synchronization  neighbor 157.x.x.x remote-as 701  neighbor 157.x.x.x filter-list 80 out ! ip as-path access-list 80 permit ^\$ ! end</pre>

The **show ip bgp summary** command output shows that 98,410 prefixes have been received from ISP-A (BGP neighbor 157.x.x.x):

```
R1# show ip bgp summary
BGP router identifier 65.yy.yy.y, local AS number XX
BGP table version is 611571, main routing table version 611571
98769 network entries and 146299 paths using 14847357 bytes of memory
23658 BGP path attribute entries using 1419480 bytes of memory
20439 BGP AS-PATH entries using 516828 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
5843 BGP filter-list cache entries using 70116 bytes of memory
```

BGP activity 534001/1904280 prefixes, 2371419/2225120 paths, scan interval 15 secs

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	State/PfxRcd
165.yy.yy.a	4	6xx9	32962	826287	611571	0	0	01:56:13	1
165.yy.yy.b	4	6xx9	32961	855737	611571	0	0	01:56:12	1
165.yy.yy.c	4	6xx9	569699	865164	611571	1	0	01:55:39	47885
<b>157.x.x.x</b>	<b>4</b>	<b>701</b>	<b>3139774</b>	<b>262532</b>	<b>611571</b>	<b>0</b>	<b>0</b>	<b>00:07:24</b>	<b>98410</b>

The **show ip route summary** command output shows that 80,132 BGP routes are installed in the routing table:

```
R1# show ip route summary
IP routing table name is Default-IP-Routing-Table(0)
Route Source      Networks      Subnets      Overhead      Memory (bytes)
connected         0             4             256           576
static            0             1             64            144
eigrp 6           0             5             768           720
bgp XX            80132        18622         6320256       14326656
  External: 87616 Internal: 11138 Local: 0
internal          854
Total              80986        18632         6321344       15322152
```

This command shows the amount of memory the BGP process occupies in RAM:

```
R1# show processes memory | begin BGP
PID TTY  Allocated      Freed      Holding      Getbufs      Retbufs Process
 73  0    678981156     89816736   70811036         0           0 BGP Router
 74  0     2968320     419750112     61388     1327064       832 BGP I/O
 75  0           0     8270540     9824         0           0 BGP Scanner
70882248 Total BGP
77465892 Total all processes
```

The BGP process is occupying approximately 71 MB of memory.

## BGP Router Configured with Inbound AS\_PATH Filter List

In this example, you apply the inbound filter list to accept routes originated by ISP-A and its directly connected autonomous systems. In the example, ISP-A is advertising a default route (0.0.0.0) via external BGP (eBGP), so routes that do not pass the filter list follow the default route toward ISP-A. This is the configuration for setting up the filter list:

```
Router 1
hostname R1
!
router bgp XX
 no synchronization
 .
 neighbor 157.x.x.x remote-as 701
 neighbor 157.x.x.x filter-list 80 out
 neighbor 157.x.x.x filter-list 85 in

!--- This line filters inbound BGP updates.

!
ip as-path access-list 80 permit ^$
ip as-path access-list 85 permit ^701_[0-9]*$

!--- The AS_PATH filter list filters ISP and the directly connected
!--- autonomous system routes.

!
```

```
end
```

This **show ip bgp summary** command output shows 31,667 prefixes received from ISP-A (neighbor 157.xx.xx.x):

```
R1# show ip bgp summary
BGP router identifier 165.yy.yy.y, local AS number XX
BGP table version is 92465, main routing table version 92465
36575 network entries and 49095 paths using 5315195 bytes of memory
4015 BGP path attribute entries using 241860 bytes of memory
3259 BGP AS-PATH entries using 78360 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
4028 BGP filter-list cache entries using 48336 bytes of memory
BGP activity 1735069/3741144 prefixes, 4596920/4547825 paths, scan interval 15 secs

Neighbor      V    AS MsgRcvd MsgSent  TblVer  InQ  OutQ Up/Down  State/PfxRcd
165.yy.yy.a   4   6319  226694 1787061   92465    0    0 17:31:04      1
165.yy.yy.b   4   6319  226814 1806986   92465    0    0 19:51:53      1
165.yy.yy.c   4   6319 1041069 1822703   92465    0    0 19:44:52    17424
157.xx.xx.x   4    701 14452518 456341    92465    0    0 19:51:37    31667
```

The **show ip route summary** command output shows 27,129 BGP routes in the routing table:

```
R1# show ip route summary
IP routing table name is Default-IP-Routing-Table(0)
Route Source   Networks   Subnets   Overhead   Memory (bytes)
connected      0           4           256         576
static         0           1           64          144
eigrp 6319     0           6           896         864
bgp 6319       27129      9424        2339392     5299332
  External: 19134 Internal: 17419 Local: 0
internal      518
Total         27647      9435        2340608     5903868
```

The memory used by the BGP process is approximately 28 MB, as shown here:

```
R1# show processes memory | include BGP
PID TTY  Allocated   Freed   Holding   Getbufs   Retbufs Process
 73  0   900742224 186644540 28115880      0         0 BGP Router
 74  0    5315232 556232160    6824   2478452    832 BGP I/O
 75  0         0 39041008    9824     0         0 BGP Scanner
28132528 Total BGP
34665820 Total all memory
```

## Troubleshoot Memory-Related Issues

To check the memory used by the BGP process, use the **show processes memory | include bgp** command. The most common issues related to an overuse of memory are listed here:

- Memory allocation failure "%SYS-2-MALLOCFAIL". For more information about this error message, refer to the document [Troubleshooting Memory Problems](#).
- Refused Telnet sessions.
- No output from some **show** commands.
- "Low on memory" error messages.
- "Unable to create EXEC – no memory or too many processes" console messages.
- Router hanging, or no console response. For more information, refer to the document [Troubleshooting High CPU Utilization on Cisco Routers](#).
- If you run BGP-related debugs, it usually causes excessive memory consumption, which can also result in memory errors due to BGP. Debugs for BGP must be run with caution and are to be avoided

if they are not required.

To store a complete global BGP routing table from one BGP peer, it is best to have a minimum of 512 MB of RAM in the router. If 256 MB of RAM is used, it is recommended that you use more route filters. If you use 512 MB of RAM, more Internet routes can be placed in the routing table with fewer route filters. On the Catalyst 6500/6000 receiving a full BGP table, it is recommended to have Multilayer Switch Feature Card 2 (MSFC2) with 256 MB of RAM to avoid Cisco bug ID CSCdt13244 ( registered customers only) . The memory consumption by BGP routes depends on the number of attributes, such as multipath support, soft reconfiguration, the number of peers, and AS\_PATH. For more details on the BGP memory requirement, refer to RFC 1774 .

Cisco Express Forwarding/distributed Cisco Express Forwarding (CEF/dCEF) switching consumes memory, depending on the routing table size. There are two main components of CEF:

- The Forwarding Information Base (FIB)
- The adjacency table

Both tables are stored in DRAM memory. Ensure that your Versatile Interface Processor (VIP) or line card also contains sufficient free DRAM. The "%FIB-3-FIBDISABLE : Fatal error, slot [#]: no memory" and "%FIB-3-NOMEM" error messages indicate insufficient memory in the cards.

It is highly recommended to check the VIP or line card memory before enabling dCEF. Complete these steps to confirm the memory:

1. Configure central CEF by issuing the **ip cef** command in global configuration mode.

Allow time for the FIB table to build.

2. Review the size of the central FIB table with the **show ip cef summary** command.
3. Determine whether the VIP or line card has sufficient available DRAM to store a similar-sized FIB table.

Issue the **show controller vip [slot#] tech** command, and check the output of the **show memory summary** command.

When running full Internet BGP routes, it is best to have at least 512 MB of RAM on the VIP or line card.

For more information about troubleshooting memory-related issues involving CEF/dCEF, refer to the document Troubleshooting Cisco Express Forwarding-Related Error Messages.

## Conclusion

This chart illustrates the memory savings by implementing the filter list:

	Number of Prefixes	Memory Consumed
No Filtering	98,410	70,882,248
Autonomous System Filter	31,667	28,132,528

When the BGP router receives its neighbors' full BGP routing table (98,410 routes), the router consumes approximately 71 MB. With the AS\_PATH filters applied to inbound updates, the size of the BGP routing table is reduced to 31,667 routes, and the memory consumption is approximately 28 MB. This decrease in

memory utilization is more than 60 percent with optimal routing.

If you review the AS Internet Graph compiled by the Cooperative Association for Internet Data Analysis (CAIDA), you can see which ISPs have the highest degree of interconnectivity (those closest to the center of the chart). With less interconnectivity, fewer routes pass through the AS\_PATH filter, and the BGP memory consumption is lower. However, it is important to note that whenever AS\_PATH filters are set, you need to configure a default route (0/0). Routes that do not pass the AS\_PATH filter list follow the default route.

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## Related Information

- **Using Regular Expressions in BGP**
- **Load Sharing with BGP in Single and Multihomed Environments: Sample Configurations**
- **How to Use HSRP to Provide Redundancy in a Multihomed BGP Network**
- **Sample Configuration for BGP with Two Different Service Providers (Multihoming)**
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